This consortial program is supported by the W.M. Keck Foundation of Los Angeles

Proposal Cover Sheet

Project Title: Redesigning Human Biology for Non-science Majors to Enhance Scientific and Quantitative Literacy

Faculty Name: Linda C. McNally

Institution: Davidson College

Faculty Department: Department of Biology

Faculty Address: Box 7118, Davidson, NC 28035-7118

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Amount requested: $9,500

Date grant submitted: December 1, 2006

Proposed grant period: January 15, 2007-January 15, 2008

Type of project: Review, redesign and reimplementation of an existing course

Signature of faculty submitting proposal Linda C. McNally

Date: 11/27/06

Dr. Verna M. Case

Name of Dept./Div. Chair

Verna M. Case

Signature of Dept./Div. Chair

Date 11/27/2006

Dr. Clark G. Ross

Name of Chief Academic Officer:

VP for Academic Affairs and Dean of Faculty

Title of Chief Academic Officer

Clark G. Ross

Signature of Chief Academic Officer

Date 11/28/2006

Evidence of institutional support is required for each mini-grant proposal in the form of a letter of support from the proposal author's Department/Division Chair or Dean of Science.

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Date received _____ By _____

Date sent to review Committee _____

Action _____ Notification sent _____

SUMMARY

While non-science majors are not likely to become scientists, they will be confronted with a variety of science-based issues throughout their lives. One of the most pervasive and unavoidable of these issues is their own health and wellbeing. Students are faced with an overwhelming amount of health and medical information in the media. They will use this information to make health decisions not only for themselves, but also for loved ones (i.e., children, aging parents, etc.). Furthermore, as voting citizens they will be presented with health and medical issues that require evaluation and decision-making (Bernstein, 1993). Thus, students need to be able to interpret and critically evaluate the information they encounter.

The goal of this proposal is to obtain funding to redesign an existing non-science majors' Human Biology course to provide students with an engaging environment that provides both scientific and quantitative literacy skills for evaluating scientific information. A wireless classroom response ("clicker") system will be used to facilitate active learning in the classroom and lab, while case studies involving contemporary and interdisciplinary issues will be used to develop problem-solving skills and student collaboration. In addition, inquiry laboratory modules will be developed to better provide students with knowledge of proper experimental design and quantitative skills for interpreting scientific data.

Students completing this course will have an increased appreciation for the relevance of science to their lives and greater confidence in dealing with scientific issues. They will gain skills for interpreting, understanding and evaluating scientific information. Ultimately, their increased scientific and quantitative literacy will allow Human Biology students to make more informed decisions regarding the science and health issues they face in the future.

PROJECT DESCRIPTION

Goal: The goal of this project is to redesign an existing Human Biology course to provide non-science majors with an active learning environment that (1) increases their appreciation for science and its relevance to their lives, (2) illustrates the interrelatedness of science and math, (3) promotes critical thinking skills.

Objectives: Human Biology students will:

1. Engage in active learning through the use of a wireless classroom response system ("clickers") to provide immediate responses to questions posed during class and lab.
2. Gain an understanding of scientific inquiry and its importance to their lives by investigating real-life problems presented as case studies.
3. Develop quantitative and analytical skills for interpreting and evaluating scientific information.
4. Apply their newly gained scientific knowledge and analytical skills in their own investigations.

Background and Significance: Teaching non-science majors has specific challenges. Many of these students feel disconnected to science and lack confidence in dealing with scientific issues (Hohman et al., 2006). Common student remarks are "I just can't do science" or "I'm not a science person." Most scientists show an inherent interest in their chosen field (or science in general) at an early age and have a sense of "belonging" in the scientific community. Non-science majors see themselves as "outsiders" to this realm and this perception may contribute to their reluctance and apprehension toward scientific study (Tobias, 1990).

Despite their own perceived inadequacies, most non-science majors are quite capable of "doing science" – they have either chosen not to try or have been unsuccessful in previous

attempts. While students ultimately bear responsibility for their own learning, ineffective teaching methods in previous science courses have strongly influenced non-science majors' attitudes and success (or lack thereof). This suggests that more effective teaching methods could have positive influences on student perceptions and outcomes (Tai et al., 2006).

I developed Human Biology as a laboratory course for non-science majors in 1995 and offer the course every semester. To date, I have primarily used a traditional lecture approach with periodic questions posed to determine comprehension, survey information or generate discussion. Previous studies indicate that traditional lecture is often insufficient for maintaining student attention or enhancing understanding and retention of information (Shulman, 1999; Tobias, 1992; Smith et al., 2005). In my own experience I have found that while some students thrive with this teaching/learning style, this pedagogy fails to build a sense of community in the classroom and perpetuates the student perception that biology is simply memorization of facts. In addition, many students are reluctant to speak up in class for fear of "saying something stupid" that will result in negative judgment from classmates and/or the instructor. Over the years I have found various ways of incorporating active and collaborative learning activities to engage students with different learning styles, facilitate learning, and enrich the classroom environment but I have been limited in my choices.

The laboratory portion of the course uses student collaboration (working in groups of four) to investigate scientific issues and perform experiments (primarily "cookbook" labs that reinforce concepts presented in the classroom). I have found that such labs result in students "going through the motions" to obtain the desired outcome, but generate little interest or insight into the scientific process itself and do not provide students with the skills needed to evaluate scientific research. Since students generally lack the basic quantitative skills needed to

understand and properly interpret scientific data (Hohman et al., 2006; Kugler et al., 2003), students are not developing the ability to properly assess scientific information they may encounter. I have incorporated occasional *ad hoc* experiments in an attempt to "uncookbook" laboratory investigations (Leonard, 1991), but feel additional inquiry activities are needed to develop students' problem-solving and analytical skills.

The funds requested through this grant will allow me to redesign Human Biology, incorporating successes from my own and colleagues' teaching experiences, to provide an active learning environment that will enhance student engagement in both the classroom and laboratory. The ultimate aim of the revised course is to provide students with an appreciation for how science is done, an understanding of why it is important, and lifelong skills to interpret and evaluate scientific information.

Detailed Project Plan: Course objectives will be fulfilled using the following strategies.

1) Classroom Response System ("clickers"): While an electronic classroom response ("clicker") system in and of itself cannot overcome preformed attitudes and perceptions that non-science majors may bring into a college science course, the purchase of the system will provide an active learning environment in the classroom and laboratory that will be a major building block in engaging students and enhancing their understanding of the scientific material presented. With this technology, students are assigned a clicker for use throughout the semester to provide electronic responses to multiple-choice questions posed by the instructor during class or lab. System software records responses and immediately generates a histogram that can be viewed by the class. Instructors can allow anonymous responses or may save a record of individual responses for later assessment. Faculty currently using clickers feel students are more engaged and attentive in their classes (Duncan, 2006). Herreid's (2006) survey of current literature

provides evidence for positive outcomes on student interest and learning in the "few formal assessments on the use of student response systems" found.

I plan to develop clicker questions to assess students on several levels to: 1) survey existing basic scientific knowledge, 2) identify scientific misconceptions, 3) determine understanding of new concepts and 4) determine ability to apply knowledge to novel situations. In the latter case, clickers will be used to facilitate pair-share discussions in which students work together to solve a problem. In addition, clickers will allow anonymous surveys regarding sensitive issues such as alcohol use, protected vs. unprotected sex, or views on abortion, stem cell research and other social/ethical dilemmas.

2) Case Study Teaching: While I have used case studies on a limited basis in the course, I would like to expand this use to incorporate more contemporary and interdisciplinary issues and enhance collaborative learning among students (see "Prior Activities" below). Cases provide students with a realistic context for scientific issues and help them work through problems by developing critical thinking and oral communication skills (Herreid, 1994). For this course, cases will be used to introduce current health issues (such as cardiovascular disease and cancer) and guide student groups in interdisciplinary investigations of underlying scientific principles and epidemiological data. For example, a cancer case will lead to an exploration of the effect of chemicals and radiation on DNA structure and function, and will examine how this relates to the incidence of cancer. Cases are also effective for introducing inquiry labs that require students to design and perform their own experiments (Dinan, 2005). Used in this context, cases will introduce students to the scientific method and the importance of controlled experiments. In addition, students will gain quantitative skills as they measure and record data, perform simple statistical analysis, and report results (see below). The National Center for Case Study Teaching

in Science website *(http://ublib.buffalo.edu/libraries/projects/cases)* will serve as a source for some of the case studies used in this course. There is no cost for using this resource.

3) Enhancement of Scientific and Quantitative Literacy: Merging math and biology concepts, case studies and inquiry laboratory modules will be developed to provide students with knowledge of the scientific process and skills to evaluate scientific data. For example, a case study requiring students to compare dietary supplements with FDA-approved prescription drugs will allow an investigation of anecdotal vs. experimental evidence, the importance of sample size and controlled experiments, and issues of bias in advertising. Quantitative skills will be gained throughout the course in a variety of contexts. An inquiry lab on body form and symmetry will allow students to take specific measurements and use these data to generate calculations of descriptive statistics (mean, median, and mode), determine ranges, examine the concept of relative size and explore sampling error. A case study on cancer will introduce students to the concept of risk analysis: absolute versus relative risk. And, an inquiry lab module on the cardiovascular system will allow students to conduct their own investigations of blood pressure and heart rate changes and perform statistical tests to analyze their data. Through this lab, students will gain an understanding of P values and the meaning of statistical significance.

Prior Activities: I began experimenting with case study teaching in Human Biology as a result of course modifications made through a Davidson College Teaching Improvement Grant received in 2005. This fall, I attended the National Center for Case Study Teaching in Sciences Conference. The conference not only provided information on using cases in teaching, but also offered sessions on the use of clickers in the classroom and the development of inquiry labs.

Projected Timetable:

Jan.-May, 2007 Gather relevant literature, background materials and case examples.

	Gather information on clicker technology; demo and purchase system.
May-Aug., 2007	Redesign course – develop clicker questions, write cases & inquiry lab modules.
Aug.-Dec., 2007	Teach revised course. Collect assessment data. Begin dissemination.

Requested Budget:

Faculty Stipend (funds for May-Aug. course revision)	$5,000
Classroom Response System (Clickers)	$3,000
Travel to 2007/2008 Conferences to present results: National Association of Biology Teachers (NABT) National Science Teachers Association (NSTA)	$1,300
Books (relative to teaching pedagogies & statistical literacy)	$ 200
TOTAL REQUESTED	$9,500

Context of Course in Curriculum, Impact on the Institution: Davidson College requires all non-science majors take at least one laboratory science course. Human Biology fulfills this core requirement for many students as the course always fills to capacity (32 seats) and is offered every semester. While the biology department generally offers one additional laboratory course for non-science majors during the academic year, Human Biology has been the only regularly offered biology course of this nature. For many Davidson College students, Human Biology is their only exposure to a college laboratory science course. I also teach a non-lab course, Bio 103 - "Microbes and Human Diseases," once each year (32 students) that fulfills the additional "non-lab" science course requirement for non-science majors. Ultimately, the pedagogies developed for Human Biology will be incorporated into this course as well.

Additionally, through discussions with colleagues and on-campus dissemination of results, this project will serve as a model for reform of teaching non-science majors in any area of science. Pedagogies used in this project can also be applied in courses for science majors.

Evidence of Institutional Support: Davidson College has an Instructional Technology Group (ITG) dedicated to the support of the use of technology in the classroom. I have been in conversation with the instructional technologist for the sciences regarding the implementation of clicker technology and the purchase of the most suitable system. The attached letter from Dr. Verna Case, Chair of the Biology Department, indicates the importance of this course in the core curriculum and institutional support for the proposed revisions.

EVALUATION, DISSEMINATION & CONTINUED SUPPORT

Evaluation: Assessment of success in meeting the course goals and objectives will be accomplished in a variety of ways. Students will be given pre- and post-course surveys to assess knowledge and attitudes toward science and math (the Science and Math Values Inventory developed by scientists at Drury University will be utilized in this capacity). In addition, clicker technology will allow surveys throughout the semester to obtain data on student comprehension and attitudes regarding the teaching/learning methods employed. Assessment of students' ability to evaluate and interpret scientific evidence will be made by comparing reasoning skills evident in early versus late semester assignments. The Davidson College end of course student evaluations will be used to provide an overview of student perception of course success and learning experience. As the questions in the end of course evaluations have remained the same for several years, I will be able to do a direct comparison of prior years with the redesigned course. Finally, to assess whether students who have completed the course maintain an

appreciation of science and its relevance to their lives, I will also conduct surveys of students one year post-graduation to determine if the course has had a lasting affect in their attitudes.

Dissemination: Dissemination of the results of this project will occur through several venues: (1) an on-campus presentation for a teaching discussion group regarding the teaching pedagogies used, (2) presentations at NSTA and NABT conferences, (3) submission of an article regarding teaching outcomes to the Journal of College Science Teaching, The American Biology Teacher or Cell Biology Education, (4) submission of new case studies written for this course to the National Center for Case Study Teaching in Science for inclusion in their online case collection, (5) posting of course materials on the course website and the instructors homepage to make them available to other institutions, and (6) providing materials for inclusion on the ACS website.

Continued Support: Once purchased, the wireless classroom response system will not need to be upgraded for several years and thus can be used by successive groups of students. The biology department has invested continued funds for the Human Biology course to purchase and maintain laboratory supplies and equipment, as well as upgrade laboratory computers on a regular basis. This support will continue during and beyond the scope of this grant, as indicated in the attached letter from Dr. Verna Case. Additionally, Davidson College provides limited funds for faculty travel to conferences; these funds will be used in conjunction with funds included in the grant budget to enhance dissemination opportunities.

LITERATURE CITED

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Dinan, F.J. 2005. Laboratory based case studies: Closer to the real world. *Journal of College Science Teaching.* 35(2): 27-29.

Duncan, D.K. 2006. Clickers in the classroom. *National Center for Case Study Teaching Conference*. University at Buffalo: Buffalo, NY.

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Leonard, W.H. 1991. A recipe for uncookbooking laboratory investigations. *Journal of College Science Teaching.* 21(2): 84-87.

Shulman, Lee. 1999. Taking learning seriously. *Change.* 31(4): 11-17.

Smith, K.A., Sheppard, S.D., Johnson, D.W. and R.T. Johnson. 2005. Pedagogies of engagement: Classroom-based practices. *Journal of Engineering Education.* Special issue on the State of the Art and Practice of Engineering Education Research. 94(1): 87-102.

Tai, R.H., Sadler, P.M. and J.J. Mintzes. 2006. Factors influencing college science success. *Journal of College Science Teaching*. 36(1): 52-56.

Tobias, Sheila. 1992. *Revitalizing Undergraduate Science: Why Some Things Work and Most Don't*. Research Corporation: Tucson, AZ.

Tobias, Sheila. 1990. *They're Not Dumb, They're Different: Stalking the Second Tier*. Research Corporation: Tucson, AZ.

DISCLOSURE STATEMENT

I will not have any other on-going grant activities that will coincide with the submitted proposal.

Curriculum Vitae - 2006

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EDUCATION

Master of Science in Biology. 1992. University of North Carolina at Charlotte.
Bachelor of Science in Biology with Honors. 1989. University of North Carolina at Charlotte. *magna cum laude*

PROFESSIONAL EXPERIENCE

Lecturer – Department of Biology, Davidson College (2000-present)
Instructor: Summer Ventures in Science and Math Program – UNC at Charlotte (1998-2004)
Teaching Associate – Department of Biology, Davidson College (1994-2000)
Visiting Lecturer – Department of Biology, Davidson College (1992-1994)
Visiting Lecturer – Department of Biology, University of North Carolina at Charlotte (1992)
Teaching Assistant – Department of Biology, University of North Carolina at Charlotte (1990-1992)
Research Assistant – Dr. Stanley S. Schneider, Department of Biology, University of North Carolina at Charlotte (1989-1990)
Instructor – Science Museums of Charlotte (1987-1989)

FUNDING

Faculty Study and Research: Teaching Improvement Grant, Davidson College, $2600, Summer 2005

AWARDS/HONORS

1991 - Graduate Teaching Excellence Award, University of North Carolina at Charlotte

PROFESSIONAL ORGANIZATIONS

National Association of Biology Teachers (NABT)
Association of College and University Biology Educators (ACUBE)
National Science Teachers Association (NSTA)
Society of College Science Teachers (SCST)

PUBLICATIONS

Mayer, K., L.C. McNally, and S.S. Schneider. 1998. Ovarian development and trophallaxis in queenless colonies of the honey bee, *Apis mellifera*. *Journal of Apicultural Research* 37: 295-297.

McNally, L.C. and S.S. Schneider. 1996. Spatial distribution and nesting biology of colonies of the African honey bee, *Apis mellifera scutellata* (Hymenoptera: Apidae), in Botswana, Africa. *Environmental Entomology* 25: 643-652.

McNally, L.C. and S.S. Schneider. 1994. Drone production and drone comb utilization in colonies of the African honey bee, *Apis mellifera scutellata* Lepeletier, in Africa. *Apidologie* 25: 547-556.

Schneider, S.S. and L.C. McNally. 1994. Developmental patterns associated with founding and swarming in colonies of the African honey bee race, *Apis mellifera scutellata* Lepeletier. *Apidologie* 25: 530-539.

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Schneider, S.S. and L.C. McNally. 1992. Seasonal patterns of foraging activity in colonies of the African honey bee, *Apis mellifera scutellata*, in Africa. *Insectes Sociaux* 39: 181-193.

Schneider, S.S. and L.C. McNally. 1992. Factors influencing seasonal absconding in colonies of the African honey bee, *Apis mellifera scutellata*. *Insectes Sociaux* 39: 403-423.

Schneider, S.S. and L.C. McNally. 1992. Colony defense in the African honey bee in Africa (Hymenoptera: Apidae). *Environmental Entomology* 21: 1362-1370.

Schneider, S.S. and L.C. McNally. 1991. The vibration dance behavior of queenless workers of the honey bee, *Apis mellifera* (Hymenoptera: Apidae). *Journal of Insect Behavior* 4: 319-332.

SELECTED PRESENTATIONS

Scientifically speaking: Getting non-science majors to talk biology. Teaching Improvement Grant Seminar, Davidson College, Davidson, NC. April 2006.

The spectrum of sexually transmitted diseases. Invited seminar for the Reproductive Health Educational Training (RHET) Group, Davidson College, Davidson, NC. 2001.

Environmental problems and the ecology of the Okavango River Delta, Botswana, Africa. Invited speaker for the Environmental Action Committee, Davidson College, Davidson, NC. 1994.

Nesting biology and colony movement patterns of the African honey bee, *Apis mellifera scutellata*, in Africa. (S. Schneider) Keynote Address, annual meeting of the USDA W-180 Project on African Honey Bees, Tucson, AZ. 1994.

The behavior and biology of the African honey bee in Africa. (S. Schneider) Annual meeting of the USDA W-180 Project on African Honey Bees, Tucson, AZ. 1993.

"Migration dances" in the African honey bee, *Apis mellifera scutellata*.. (S. Schneider) Entomological Society of America, Baltimore, MD. 1992.

Factors influencing colony defensive behavior in the African honey bee. (S. Schneider) Animal Behavior Society, Kingston, Ontario. 1992.

Seasonal cycle of colony development in the African honey bee in Africa. (S. Schneider) Entomological Society of America, Reno, NV. 1991.

Factors influencing migration in the African honey bee. Animal Behavior Society, Wilmington, NC.. 1991.

Absconding behavior of the African honey bee. Association of Southeastern Biologists, Charlotte, NC. 1989.

The Mechanisms of Aggression in Honeybee Colonies. (S. Schneider) Association of Southeastern Biologists, Charlotte, NC. 1989.

COURSES TAUGHT AND DEVELOPED

Human Biology (Bio104) - lecture and lab
Organismal Biology (Bio112) – lecture and lab
Microbes and Human Disease (Bio103)
Environmental Issues (Bio103)

ADDITIONAL COURSES TAUGHT

Evolution (Bio342 – team taught)
General Biology (Bio1110) - UNC-Charlotte
Medical Genetics - Summer Ventures in Science and Math Program, UNC-Charlotte

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November 28, 2006

ACS Science Education Initiative
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To the Committee:

As Chair of the Department of Biology at Davidson College, I am writing in support of Linda McNally's proposal for a new course development grant through the ACS Reform of Science Education for Non-Science Majors Initiative. Ms. McNally has been teaching most of our non-majors biology courses for over ten years and she has been doing a wonderful job introducing the students to biological information and concepts that are relevant to their lives.

Ms. McNally recently attended a workshop focusing on the case studies approach to teaching. She proposes to adapt what she learned in this workshop to the courses she teaches at Davidson. She and I have talked frequently about the value of the case study approach. I think that her proposal to ACS will allow her to explore this pedagogy and to achieve her goals for our non-majors courses. I commend Ms. McNally's plan to incorporate more quantitative techniques in her courses. The merger of math and biology is recommended in the National Academies *Bio2010*, so Ms. McNally's proposal is timely and consistent with our departmental goals. Finally, I was pleased to see that Ms. McNally plans to make use of the clicker technology. I think that the use of clickers will be very effective in the non-majors courses. Non-majors are often reluctant to jump into "science" discussions because they are intimidated by and fearful of the subject. Clickers can overcome students' fear of "looking stupid", help students become active class participants without risk, and increase student engagement with course material.

In summary, I enthusiastically support this proposal and the Department will fully support Ms. McNally's efforts in developing new material for our non-majors courses.

Sincerely yours,

Verna Miller Case, Ph.D.
Chair and Professor of Biology
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